Vol. 85, No. 8, pp. 109–130 30 August 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

COMMENTS ON THE ECHINOID GENUS *ENCOPE*, AND A NEW SUBGENUS

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Two species of the sand dollar *Encope* occur in the coastal waters of eastern Mexico and the United States from the northern tip of the Yucatan Peninsula to Cape Hatteras. They are *Encope michelini* L. Agassiz and *Encope aberrans* Martens. A third species *E. emarginata* (Leske) is restricted to Caribbean and Atlantic coastal waters south of the Yucatan Peninsula. Unfortunately A. Agassiz (1872, p. 126) considered *E. aberrans* a junior synonym of *E. michelini*. This and a typographical error in one of his plate explanations has led to misidentifications of *Encope* specimens collected from Cape Hatteras to the Yucatan Peninsula.

The misidentifications were generally as follows: 1. Specimens of both *E. michelini* and *E. aberrans* were identified as *E. michelini*. 2. Specimens of *E. michelini* were identified as *E. emarginata* and specimens of *E. aberrans* were identified as *E. michelini*. 3. Specimens of *E. michelini* and *E. aberrans* were both identified as *E. emarginata*.

The following distinctive features from the original descriptions and illustrations clearly delineate the three species.

E. emarginata: The original figures (Leske 1778, Pl. 50, Figs. 5, 6) show a completely closed notch forming a lunule in ambulacrum V. The other four notches are closed but a fine line in the drawing indicates that a complete bridging at the notch openings has not occurred. Leske compared this species with *Echinodiscus sexiesperforatus* Leske (1778, Pl. 50, Figs. 3, 4) and states that it differs in that the holes reach

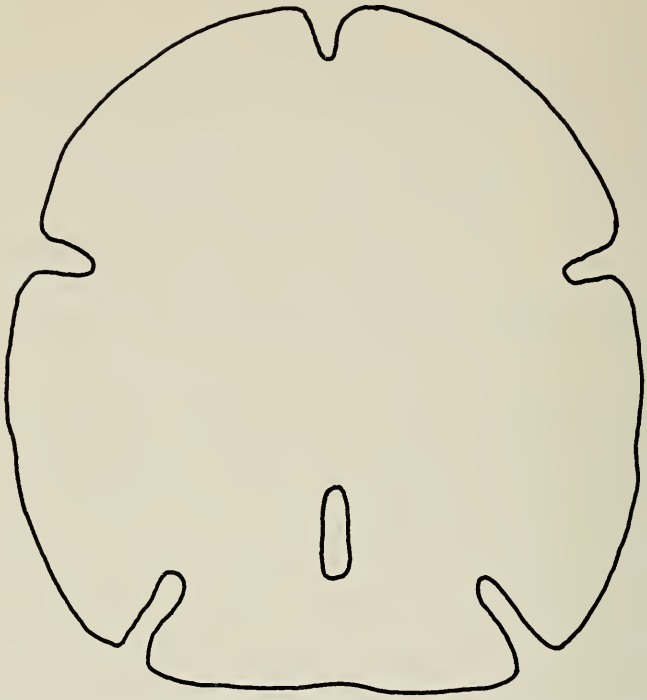

Fig. 1. Tracing of the original figure of *Encope michelini* L. Agassiz (1841, Plate 6a, Fig. 9). Note the uniform notches. Figure reduced by one-third.

to the very margin thus forming five incisions. Leske does not mention the position of the apex of the test.

Leske reported that the specimen was sent from the island of Bourbon (now Reunion) to the Reamur Museum. This locality must be in error as the genus *Encope* is restricted to the coastal waters of the Americas. In fact no echinoid species with a closed odd posterior interambulacral lunule is known to occur in the Indian Ocean.

E. michelini: L. Agassiz (1841, p. 58) stated that the notches are medium deep, uniform, the posterior ones slightly deeper than the anterior three with no tendency to close. The apex of the test is between the apical system and the posterior

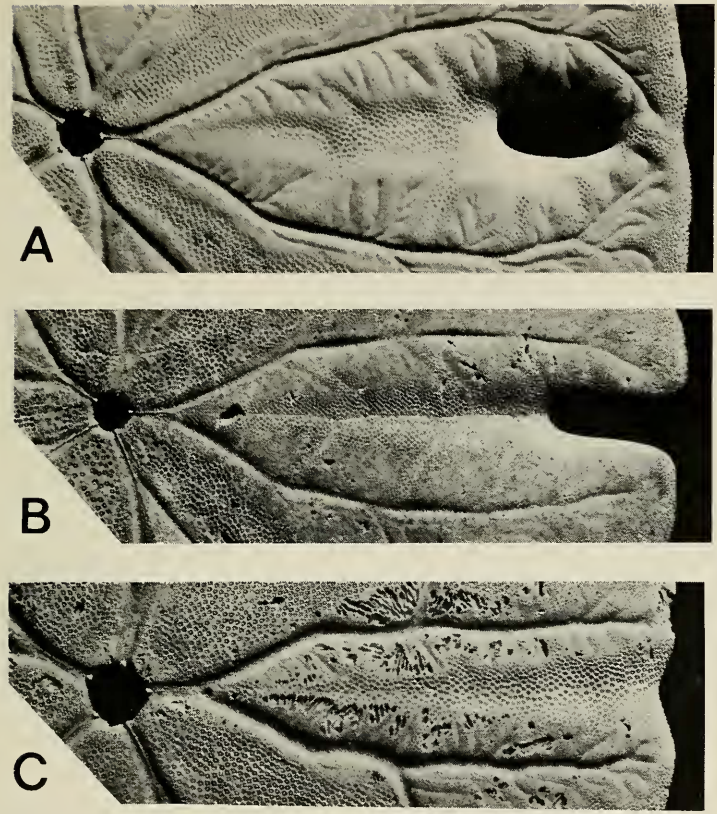

FIG. 2. A comparison of the notches; ambulacral midline depression; food groove shape, depth, and width; and peristome size. A. *Encope emarginata* length 125.4 mm, USNM 8421, × 1.5. B. *Encope* ~~*emarginata*~~ *micheli* length 115 mm, USNM 170549, × 1.5. C. *Encope aberrans* length 114 mm, USNM 170548, × 1.5. All views are of the adoral surface of Ambulacra IV.

interambulacral lunule. A tracing of the original adapical view is shown in Figure 1.

E. aberrans: The odd and paired anterior notches are only slight indentations (schwache Einkerbungen). Posterior paired notches are short (kurze Einschnitte). The odd posterior lunule is about as long as the depth of a posterior notch, and is anterior to the tips of the posterior ambulacral petals.

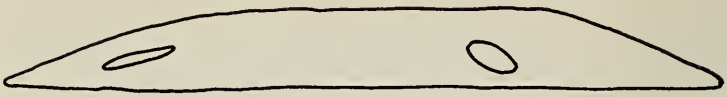

FIG. 3. Profile of right side of *Encope emarginata* (Leske), length 125.4 mm, Sabanilla, Columbia, USNM 8421.

E. aberrans is distinct from *E. michelini* and *E. emarginata* by its weak development of notches. The posterior notches are short (kurze Einschnitte), the anterior ones mere indentations (blosse Einkerbungen).

The differences between the three species are described in Table I.

E. aberrans is distinct from *E. michelini* as there are no mature specimens with an intermediate condition between the deep notches of *E. michelini* and the slight indentations of *E. aberrans*. There is a marked difference between the ratio of peristome diameter to specimen length in these two species. The food grooves of *E. aberrans* are relatively wider, deeper, and more angular than those of *E. michelini* (Figs. 2B, C, 7, 10). There is a deep depression in each ambulacrum between the two main branches of the food grooves in *E. michelini*. The corresponding depressions on *E. aberrans* are very shallow.

Populations of the two species commonly do not mix. I have been informed by I. E. Gray, Duke University Marine Laboratory (personal communication, 1971) that dredge hauls off North Carolina with a large number of *Encope* specimens usually contain one species, either *E. michelini* or *E. aberrans*. When the two species are collected together one of them occurs in small numbers. I found the same kind of distribution in the *Encope* collections in the National Museum of Natural History.

I believe the two species prefer a bottom sediment of different particle size. The differences in food groove depth and width, peristome size, and adoral ambulacral midline depression all indicate that the two species are adapted to a different feeding condition. It is known that the distribution of some sand dollars is strongly related to sea floor particle

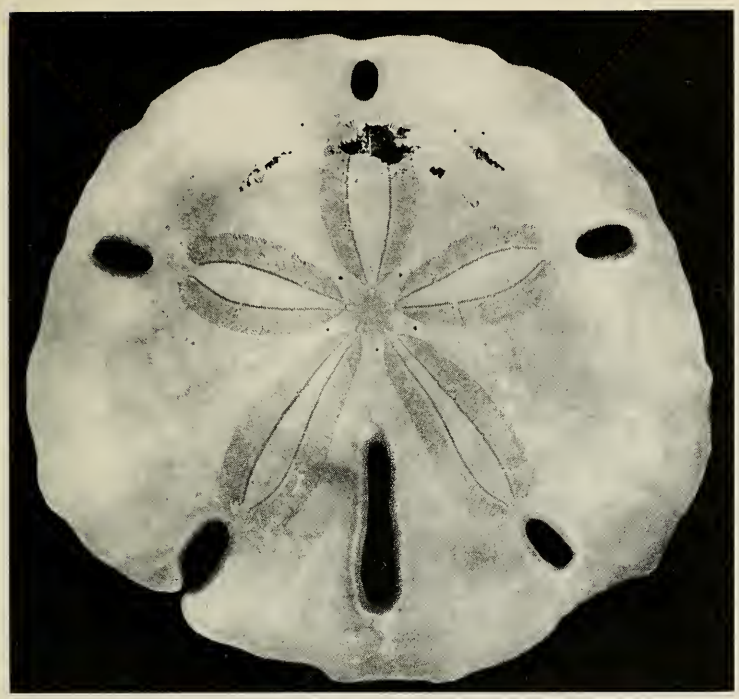

FIG. 4. Adapical view of *Encope emarginata* (Leske), same (same specimen as Fig. 3).

size as shown by Stanley and James (1971) for the distribution of *Echinarachnius parma.*

Features of *E. emarginata* which make it distinct from both *E. michelini* and *E. aberrans* are:

1. Two ambulacral plates and the first pair of post basicoronal interambulacral plates are in contact with the the periproct. Rarely only one plate of the first interambulacral pair is in contact with the posterior portion of the periproct. Durham (1955) emphasized the taxonomic importance of the adoral plate arrangement in in the clypeasteroid echinoids.
2. The five ambulacral notches close or have a strong tendency to close forming lunules (Figs. 2A, 4).
3. The apex of the test is a long flattened area extending

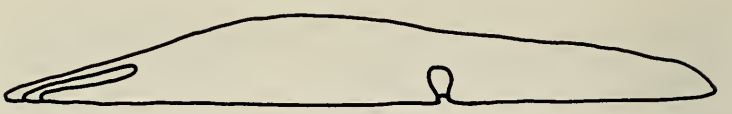

Fig. 5. Profile of right side of *Encope michelini* A. Agassiz, length 112.6 mm, USNM 174444.

from anterior to the apical system to the posterior odd lunule. The highest point is commonly anterior to the apical system (Fig. 3).

Lütken (1864, p. 43) considered *E. michelini* and other eastern American Recent *Encope* echinoids junior synonyms of *E. emarginata*. Although most subsequent authors are in agreement on South and Central American species, they do not agree that *E. michelini* is only a local variety of *E. emarginata* (see A. Agassiz 1872, p. 329).

I believe Alexander Agassiz overlooked several significant differences between *E. michelini* and *E. aberrans* when he considered *E. aberrans* a junior synonym of *E. michelini* (A. Agassiz 1872, p. 126). He presented no reasons for his action in the redescription of *E. michelini* (A. Agassiz 1872, p. 329).

Agassiz' only illustration of an *E. michelini* specimen is Plate 12d, figure 1 (A. Agassiz 1872), but a typographical error in the plate explanation incorrectly identifies it as *E. emarginata*. His reference to this figure in the text is correct. His other illustrations of *E. michelini* (Pl. 12b, Fig. 4; Pl. 12c, Figs. 3, 4) are all of specimens of *E. aberrans*.

A. Agassiz reported *E. emarginata* from South Carolina to Rio de Janeiro (A. Agassiz 1872, p. 233). I have been unable to find any specimens from the Gulf of Mexico or in the Atlantic waters of the United States. I do not believe it occurs in this region. Clark (1914, p. 74) also doubted the occurrence of *E. emarginata* in the coastal waters of the United States.

Mortensen (1948, p. 441) concurred with A. Agassiz' (1872) opinion. In his description of *E. michelini* Mortensen described the anterior notches as small indentations in the margin of the test; a diagnostic feature of *E. aberrans*. He had one

Fig. 6. Adapical view of *Encope michelini* L. Agassiz (same specimen as Figs. 5, 7).

specimen of *E. michelini* on hand from Charlotte Harbor, Florida, similar to Agassiz' figured specimen (A. Agassiz 1872, Pl. 12d, Fig. 1). Mortensen recognized it as *E. michelini* and commented on its rather deep marginal slits, but did not discuss the differences in the margin due to his lack of specimens for study. He overlooked differences on the adoral surface (see Diagnoses) and continued to recognize *E. aberrans* as a junior synonym of *E. michelini.*

W. Berry (1941) compared fossil and Recent specimens identified as *E. michelini.* The fossil specimens (Pl. 63, Figs. 1, 3, 7; Pl. 64, Figs. 1–6; Pl. 65, Figs. 1, 2) are here identified as *E. michelini.* The Recent specimens from Albatross Station 2609 (Pl. 63, Figs. 2, 5, 8) are specimens of *E. aberrans.* I have not tried to identify the juvenile specimens (Pl. 63,

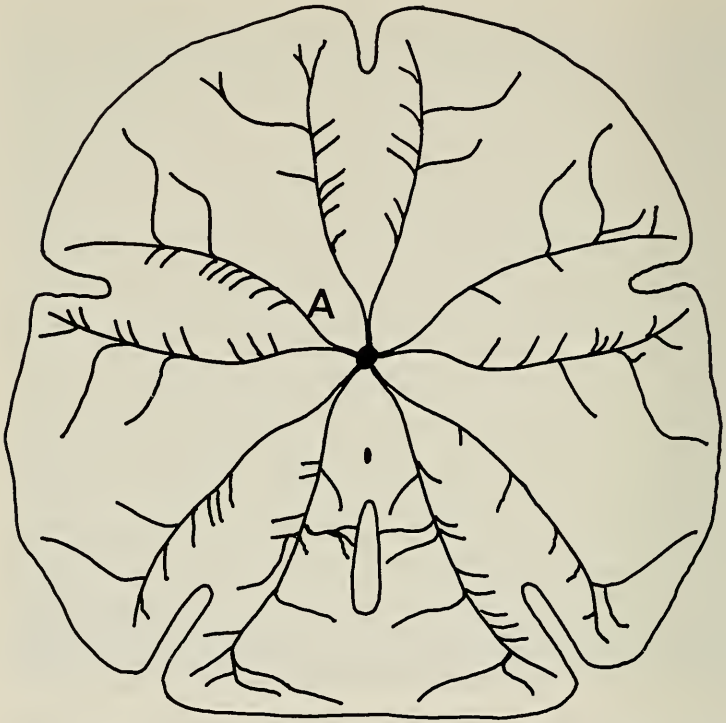

Fig. 7. Adoral view of *Encope michelini* L. Agassiz, length 112.6 mm; note the narrow curving food grooves and small peristome, USNM 174444.

Figs. 4, 6; Pl. 65, Figs. 3, 4, 6). The food groove and peristome size differences of the two *Encope* species are well illustrated by the two side-by-side photographs (Pl. 63, Figs. 7, 8).

Cooke (1942, p. 20, Pl. 3, Figs. 14, 15) reported finding fossil specimens of *E. emarginata* in the Carolinas. These specimens [*Mellita carolinana* (Ravenel)] are strikingly similar to but are not *E. emarginata* (see material examined under *E. emarginata* and the section on *Encope* posterior plate arrangement).

Cooke recognized that two distinct *Encope* species inhabited the coastal waters of the United States and occurred as fossils. Specimens of *E. michelini* he identified as *E. emarginata*

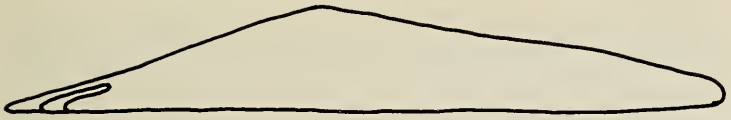

FIG. 8. Profile of right side of *Encope aberrans* Martens, length 113.1 mm, Tampa Bay, Florida, USNM 174443.

(Cooke 1959, Pl. 17, Fig. 5; Pl. 18, Fig. 1) and specimens of *E. aberrans* he identified as *E. michelini* (Cooke 1959, Pl. 18, Figs. 2, 3). Figuratively, although not literally, he was placing *E. michelini* in synonymy with *E. emarginata* and recognizing *E. aberrans* as a distinct species, because in his opinion all the features of *E. michelini* as described by L. Agassiz (1841, p. 58) were attributable to *E. emarginata.* The diagnostic features of *E. aberrans* (Martens 1867, p. 112) are the ones he retained for *E. michelini.* Cooke's opinion strengthened the widespread belief that *E. emarginata* occurred in the coastal waters of the United States.

Cooke (1961, p. 17, Pl. 6, Figs. 5, 6; Pl. 7, Fig. 5) reported fossil specimens of *E. michelini* from the Miocene of Venezuela. These are specimens of *E. aberrans.*

An unusual fossil population of *E. aberrans* was found and reported by Kier (1963, p. 33, Pl. 5, Fig. 1; Pl. 6, Figs. 3, 4; Text-figs. 25–30). I believe this population has more variation than expected in a normal population. The posterior interambulacral lunule size ranges from about the smallest normal size for *Encope aberrans* to complete lack of a lunule. The subspecies designation *E. michelini imperforate* Kier was due to the common opinion of many workers that specimens of *E. michelini* were *E. emarginata* and specimens of *E. aberrans* were *E. michelini.* It is evident that two species have commonly been recognized in the United States and its coastal waters.

Ceramc-Vivas and Gray (1966, p. 263) reported collecting specimens of *E. emarginata* off the coast of North Carolina. Gray kindly sent specimens for me to examine, and they proved to be specimens of *E. michelini* and *E. aberrans.* Although he referred both species to *E. emarginata*, Gray (personal com-

FIG. 9. Adapical view of *Encope aberrans* Martens (same specimen as Figs. 8, 10).

munication, 1971) has informed me that he believes two species of *Encope* occur off the North Carolina coast.

Definition of terms: In the following diagnoses the terms large, medium, and small are used to indicate the relative size of a feature as compared to its equivalent on the other two of the three species.

Encope emarginata (Leske) 1778

Figures 2A, 3, 4; Tables I, II.

Echinodiscus emarginatus Leske 1778, p. 136; Pl. 50, Figs. 5, 6.

Encope emarginata Agassiz, L. 1841, p. 47; Pl. 10, Figs. 1–6.—Agassiz, A. 1872, p. 325; Pl. 12b, Figs. 1–3; Pl. 12d, Figs. 2, 3 (not Pl. 12d, Fig. 1).—Durham 1955, p. 97; Fig. 17D. For additional synonymy see Mortensen 1948, p. 438.

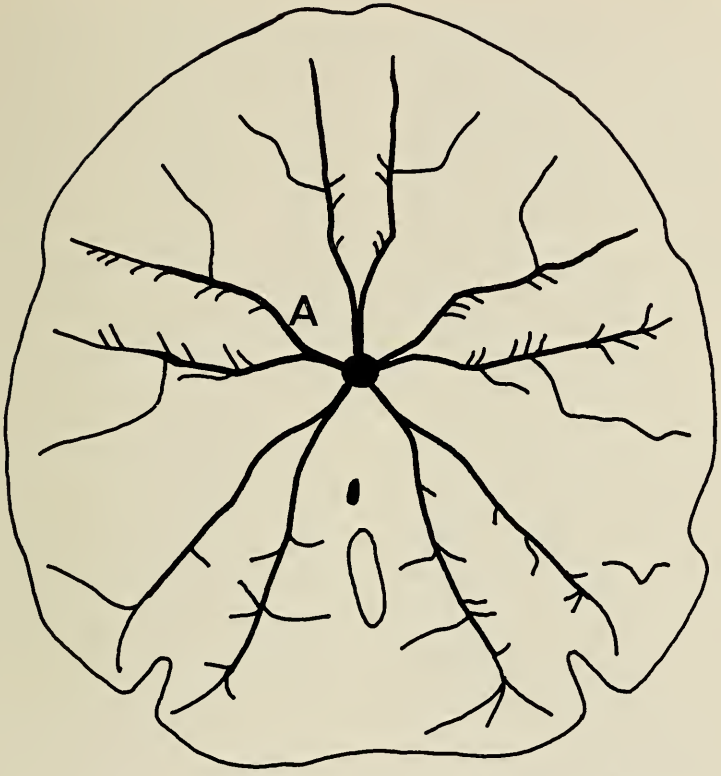

Fig. 10. Adoral view of *Encope aberrans* Martens, length 113.1 mm, note wide angular food grooves, large peristome, and slight indentations insead of notches in the margins of ambulacra II, III and IV. "A" is the point where food groove was measured on 10 specimens; USNM 174443.

Diagnosis: The adoral surface of the test is flat. Height is approximately 10 percent of the length. A long flattened area extends lengthwise across the apical system (Fig. 3) with the highest point commonly anterior to the apical system although on some specimens it is at a thick anterior edge of the posterior odd lunule. The large posterior interambulacral lunule is approximately 21 percent of specimen length. The five notches are nearly uniform, commonly closed to form lunules (Figs. 2A, 4). Open notches show a strong tendency to close (see left posterior notch, Fig. 4). The food grooves turn in gentle curves and are of medium width. There is a medium deep depression

TABLE I. Distinctive features of *E. emarginata*, *E. michelini*, and *E. aberrans*.

	E. emarginata	*E. michelini*	*E. aberrans*
Ambulacral notches.	Closed, forming lunules or a very strong tendency to close (Figs. 2A, 4).	The three anterior deep, no tendency to close, posterior two deeper than the three anterior ones, posterior two have a slight tendency to close (Figs. 1, 2B, 6, 7).	The three anterior only slight indentations of the margin, depth of posterior two approximately equal to 1/12 specimen length (Figs. 2C, 9, 10).
Apex of the test.	A broad flattened zone extending from anterior of apical system to the posterior odd lunule, commonly with the highest point anterior of the apical system (Fig. 3).	Between the apical system and the posterior lunule (Fig. 5).	Between the apical system and the posterior lunule (Fig. 8).
Peristome (comparative).	Intermediate (Fig. 2A).	Small (Figs. 2B, 7).	Large (Figs. 2C, 10).

TABLE I (continued)

	E. emarginata	*E. michelini*	*E. aberrans*
Food grooves (comparative).	Intermediate width and depth, curving turns (Fig. 2A).	Narrow, shallow curving turns (Figs. 2B, 7).	Wide, deep, angular turns (Figs. 2C, 10).
Depth of adoral ambulacral midline depression.	Intermediate (Fig. 2A).	Deep (Fig. 2B).	Shallow (Fig. 2C).
Plates in contact with periproct.	Two ambulacral plates and first pair of post basicoronal interambulacral plates.	First pair of post basicoronal interambulacral plates.	First pair of post basicoronal interambulacral plates.
Posterior interambulacral lunule.	Large (Fig. 4). Distal end of posterior petals align at about midpoint of lunule.	Medium (Figs. 1, 6). Distal end of posterior petals align at about midpoint of lunule.	Small (Fig. 9). Distal end of posterior petals align with posterior edge of lunule.

TABLE II. Statistics based on measurements of ten mature specimens of each species. Measurements are in millimeters. Standard deviation (S.D.) and variation coefficient (V.C.) are based on the means of the ratio: measured value/~~wave~~-length.

	E. emarginata	*E. michelini*	*E. aberrans*
Length:			
Greatest	140.7	117.2	143.3
Least	124.8	89.7	103.7
Mean	135.2	106.3	125.0
Width:			
Greatest	149.2	115.2	140.7
Least	128.8	90.7	98.9
Mean	138.1	104.0	120.8
S.D.	.032	.030	.016
V.C.	3.18	3.06	1.67
Height:			
Greatest	16.4	13.1	21.2
Least	13.3	8.3	15.1
Mean	14.4	10.7	18.2
S.D.	.006	.007	.014
V.C.	4.44	8.79	10.09
Distance between peristome and periproct:			
Greatest	16.0	10.9	23.6
Least	12.7	7.8	13.6
Mean	14.0	9.7	18.2
S.D.	.008	.005	.015
V.C.	8.54	6.03	10.44
Width of food groove:			
Greatest	1.00	.70	1.8
Least	.70	.40	1.2
Mean	.84	.51	1.4
S.D.	.0005	.0008	.001
V.C.	8.80	16.13	9.76
Depth of posterior paired notches:			
Greatest	28.1	21.8	13.7
Least	17.6	15.4	4.7
Mean	23.6	18.5	9.4
S.D.	.021	.008	.023
V.C.	12.03	5.12	30.49

Table II (continued).

	E. emarginata	*E. michelini*	*E. aberrans*
Depth of anterior paired notches:			
Greatest	21.4	14.2	4.40
Least	16.8	9.7	2.00
Mean	19.4	11.9	2.81
S.D.	.007	.007	.005
V.C.	5.30	6.53	24.62
Depth of anterior odd notch:			
Greatest	16.5	11.8	3.00
Least	13.7	8.4	.90
Mean	14.9	10.0	1.83
S.D.	.005	.005	.005
V.C.	5.31	5.87	33.89
Length of interambulacral lunule:			
Greatest	38.7	15.9	11.6
Least	17.8	10.1	8.1
Mean	28.9	12.8	9.6
S.D.	.045	.016	.0001
V.C.	21.48	13.22	14.82

in the ambulacral midline between the food grooves (Fig. 2A). The peristome is medium size. The periproct is almost completely enclosed by two ambulacral plates (Ia2 and Vb2). The first pair of posterior post basicoronal plates makes contact at the posterior edge of the periproct.

Material examined: Collections of Recent specimens at the National Museum of Natural History, USNM 8421, Sabanilla, Columbia; USNM E8102, Columbia; USNM E7862, USNM E533, USNM E539, Brazil; USNM E4695, Isle of Love; R. Chesher Collection, Caribbean coast of Panama, USNM uncatalogued; University of California, 33792, Locality A-4882, Desterro (now Florianapolis), Brazil (Durham 1955, p. 97, Fig. 17D).

The late Miocene specimens reported (Cooke, 1942) as *E. emarginata* have the interambulacral plates surrounding the periproct as in the genus *Mellita*. Approximately one-quarter of the specimens have five genital pores instead of four. These specimens are not considered *E. emarginata*: USNM 166525 (Cooke 1942, Pl. 3, Figs. 14, 15), large collection USGS locality 17733 Intercoastal Waterway, South Carolina, USNM uncatalogued.

Distribution: Caribbean coast of Central and South America, Atlantic

coast of Brazil. Depth approximately 20–70 fathoms (based on USNM collections).

Encope michelini L. Agassiz 1841

Figures 1, 2B, 5, 6, 7; Tables I, II.

Encope michelini Agassiz L. 1841, p. 58; Pl. 6a, Figs. 9, 10.—Agassiz, A. 1872, p. 330 (in part), Pl. 12d, Fig. 1 (not Pl. 12c, Figs. 3, 4; Pl. 12b, Fig. 4. These are *E. aberrans.*).—Mortensen 1948, p. 442 (in part), portion referring to a specimen from Charlotte Harbor only.—Caso 1961; Fig. 113.—Kier and Grant 1965, p. 33 (in part); Pl. 5, Fig. 7; Pl. 6, Figs. 9, 10; Pl. 7, Figs. 1–8; Pl. 15, Fig. 7; Text-fig. 7.

Encope emarginata Cooke 1959, p. 49; Pl. 17, Fig. 5; Pl. 18, Fig. 1 (not Pl. 18, Figs. 2, 3. These are *E. aberrans.*).

Diagnosis: The adoral surface of the test is flat. Height is approximately 11 percent of specimen length. The apex of the test (Fig. 5) is between the apical system and the posterior lunule. The medium sized lunule opening is approximately 12 percent of specimen length. Notches are open, deep and uniform. The posterior notches are a little deeper than the three anterior ones. None of the notches close to form lunules but the two posterior ones are slightly narrowed at the openings (Figs. 1, 6). I examined one fossil specimen (USNM 174698) in which the posterior notches were closed by a slight bridging across the opening. Berry (1941, Pl. 64, Fig. 6) illustrated a fossil with the right posterior notch closed in similar fashion. These are uncommon occurrences.

I have not seen any Recent specimens with closed notches. On Recent specimens that I observed with very narrow anterior notches the sides of the openings were parallel with no tendency to close. Food groves (Figs. 2B, 7) are shallow, very narrow, and turn in gentle curves toward the peristome. A deep depression extends down the ambulacral midline from each notch. The peristome (Figs. 2B, 7) is small. The periproct is entirely enclosed by the first posterior pair of post basicoronal interambulacral plates. These plates extend into the posterior lunule. The series of plates in interambulacrum 5 is uninterrupted by ambulacral plates. It is interrupted in *E. emarginata.* I consider this an important diagnostic feature distinguishing this species from *E. emarginata.*

Juvenile specimens of *E. emarginata,* with notches not yet closed to form lunules, superficially resemble specimens of *E. michelini.* A juvenile specimen of *E. emarginata* 73.7 mm in length figured by Durham (1955, p. 97, Fig. 17D) has a marginal outline very similar to specimens of *E. michelini,* but not that two ambulacral plates (Ia2 and Vb2) and the first pair of posterior interambulacral plates are in contact with the periproct. This specimen was incorrectly reported

from the Gulf of Mexico, but was collected off Desterro (now Florianopolis), Brazil.

Prior to the development of the three anterior notches, juvenile specimens of *E. michelini* have a marginal outline similar to specimens of *E. aberrans*, but the small peristome in *E. michelini* can be used to distinguish between these two species except in the case of very small specimens.

Material examined: Collections at the National Museum of Natural History, USNM 174444, 12 miles southeast of Sapelo Island, Georgia; USNM 562282 (fossil), South Carolina figured as *E. emarginata* (Cooke 1959, Pl. 17, Fig. 6; Pl. 18, Fig. 11); USNM 174698 (fossil), South Carolina, large collection USNM uncatalogued Sister Rock, Florida Keys; Duke University Eastward Cruise E-33-67, Station 7702.

Distribution: Cape Hatteras, North Carolina, to northeastern coast of Florida, Florida Keys, Florida and Texas Gulf Coasts, northern coast of Yucatan Peninsula. Depth 6 to 90 meters (based on USNM collections).

Encope aberrans Martens 1867

Figures 2C, 8, 9, 10; Tables I, II.

Encope aberrans Martens 1867, p. 112.

Encope michelini A. Agassiz 1872, p. 330 (in part); Pl. 12b, Fig. 4; Pl. 12c, Figs. 3, 4 (not Pl. 12c, Fig. 1).—Berry 1941 (in part); Pl. 63, Figs. 2, 5, 8 (not Pl. 63, Figs. 1, 3, 7; Pl. 64, Figs. 1–6; Pl. 65, Figs. 1, 2).—Mortensen 1948 (description in part), p. 442 (only the portion describing the indentations of the margin and the vortex of the test).—Cooke 1959, Pl. 18, Figs. 2, 3.—Cooke 1961, p. 17; Pl. 6, Figs. 5, 6; Pl. 7, Fig. 5.

Encope michelini imperforata Kier 1963, p. 35; Pl. 5, Fig. 1; Pl. 6, Figs. 3, 4; Text-figs. 25–30.

Diagnosis: The adoral surface of the test is flat. Height is approximately 15 percent of the length. The apex of the test is situated between the apical system and the small posterior interambulacral lunule (Fig. 8). The small lunule opening is approximately 8 percent of the length of the specimen (Fig. 9). Notches of the posterior paired ambulacra are small. Depth is approximately 7 percent of specimen length. There is no tendency for the notches to close. Notches of the anterior odd and paired ambulacra are very shallow to slight indentations (Figs. 2C, 9). Some fossil specimens have slightly deeper V-shaped notches and indentations than found on Recent specimens. Food grooves (Figs. 2C, 10) are deep and very wide, even prominent with spines in place. The turns of the food grooves are very angular. There is a very shallow depression in the ambulacral midline between the food grooves. The peristome is large (Figs. 2C, 10), very noticeably larger than in specimens of *E. michelini*. The periproct is completely

enclosed by the first posterior pair of post basicoronal interambulacral plates. These plates extend into the small posterior lunule. The series of plates in interambulacrum 5 is uninterrupted as in *E. michelini*.

Type-locality: Campeche Bay, Mexico.

Material examined: Collections of Recent specimens at the National Museum of Natural History, USNM 12940, Albatross Station 2609; USNM 174443, Tampa Bay, Florida; USNM 562283, Gulf of Mexico, two miles off Longboat Key, Florida, figured as *E. michelini* (Cooke 1959, Pl. 18, Figs. 2, 3); USNM uncatalogued collection dredged off South Carolina; Duke University specimen, Eastward Cruise E-25-66, Station 4941; fossil specimen from the Miocene of Venezuela, USNM 638631 figured as *E. michelini* (Cooke 1961, Pl. 6, Figs. 5, 6; Pl. 7, Fig. 5); specimens figured as *E. michelini imperforata* Kier (1963, p. 33; Pl. 5, Fig. 1; Pl. 6, Figs. 3, 4; Text-figs. 25–30); USNM 648169, USNM 648167 (Holotype), USNM 648170, USNM 648168, USNM 648171, USNM 648172, and 10 USNM uncatalogued specimens.

Conclusions: A detailed examination of collections indicates that *E. emarginata* does not occur off the Atlantic and Gulf coasts of the United States. A study of the adoral food gathering surface on specimens of *E. michelini* and *E. aberrans* indicates distinct differences in food groove width, depth and shape, and peristome size. Populations of the two species tend to inhabit separate zones even when geographically in close proximity to each other. A study of the variation in marginal indentations, notches, and posterior interambulacral lunules indicates a wide separation between these two species. As a result I believe *E. aberrans* is a distinct species from *E. michelini* and henceforth should not be considered by echinoid workers as a junior synonym of *E. michelini*.

Posterior Plate Arrangement

After completing the foregoing study I checked the interambulacrum 5 plate arrangement of other available *Encope* species to determine which had post basicoronal interambulacral plates in contact with the basicoronal interambulacral plate (continuous series), and which had post basicoronal ambulacral plates Ia2 and Vb2 interrupting the series (interrupted series). See Durham 1955, p. 174, figures 16a, 17c, d.

Species with a continuous series [*Encope* (*Encope*) L. Agassiz]:

E. aberrans Martens
E. grandis L. Agassiz (periproct in contact with basicoronal plate)
E. michelini L. Agassiz
E. tamiamiensis Mansfield (fossil)
E. platytata Jackson (fossil)

Species with an interrupted series [*Encope* (**Echinadesma**) new subgenus]:

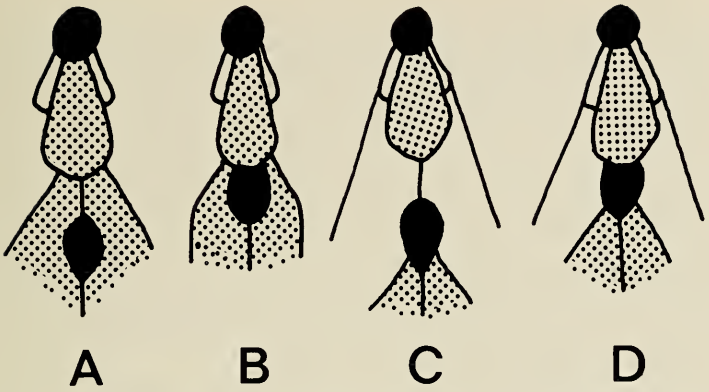

Fig. 11. Continuous and interrupted series of posterior interambulacral plates occurring in *Encope* echinoids. A. Continuous series with only the first pair of post basicoronal plates in contact with the periproct. B. Continuous series, periproct in contact with basicoronal plate and first pair of post basicoronal plates. C. Interrupted series, ambulacral plates Ia2 and Vb2 and first pair of post basicoronal interambulacral plates in contact with periproct. D. Interrupted series, periproct in in contact with basicoronal plate, ambulacral plates Ia2 and Vb2, and first pair of post basicoronal interambulacral plates. A and B illustrate the plate arrangement in the subgenus *Encope* (*Encope*) L. Agassiz. C and D are of the new subgenus *Encope* (*Echinadesma*).

E. emarginata (Leske) (including *E. valenciennesii* L. Agassiz)
E. micropora L. Agassiz (including *E. californica* Verrill and *E. irregularis* H. Clark)
E. perspectiva L. Agassiz (periproct in contact with basicoronal plate)
E. wetmorei A. Clark (periproct in contact with basicoronal plate)
E. secoensis Cooke (fossil).

Conclusions: The genus *Encope* has two basic interambulacrum 5 plate series arrangements, continuous and interrupted. Both arrangements occur in fossil and Recent species, and in Recent Atlantic and Pacific species. Each group has species with the periproct in contact with the basicoronal plate, therefore there are four general patterns of plates surrounding the periproct (Fig. 11).

The continuous series in interambulacrum 5 is the more primitive form, but the periproct has migrated toward and made contact with the basicoronal plate in species with the interrupted and continuous series indicating parallel evolution. All *Encope* species with interambulacrum 5 interrupted by ambulacral plates Ia2 and Vb2 (Fig.

11C, d) are assigned to the new subgenus *Encope* (*Echinadesma*) with *Encope* (*Echinadesma*) *micropora* L. Agassiz designated the type-species. The name *Echinadesma*, derived from Echin[os]: Gr. spiny a: Gr. not desm[os]: Gr. linked, indicates the lack of a continuous series of plates in interambulacrum 5. All *Encope* species with a continuous series of plates in ambulacrum 5 (Fig. 11A, B) are assigned to the subgenus *Encope* (*Encope*) L. Agassiz with *Encope* (*Encope*) *grandis* L. Agassiz the type species by original designation. I believe the genus *Mellita* evolved from the continuous interambulacrum 5 stock of *Encope*. *Mellita carolinana* (Ravenel) from the upper Miocene of South Carolina probably is very close to the base of the *Mellita* stock. It has the massive calcite test of *Encope*, approximately 25 percent of the specimens have five genital pores but the periproct is inserted well into the basicoronal plate.

Material examined: *E.* (*Encope*) *aberrans* USNM 170549, dredged off South Carolina; USNM 638631 Miocene of Venezuela; *E.* (*Encope*) *grandis* USNM E7455 Bahia Adair, Lower California; *E.* (*Encope*) *michelini* USNM 174698, Pleistocene, near Myrtle Beach, South Carolina; USNM uncatalogued, large collection from west of Sister Rock, Florida Keys; *E.* (*Encope*) *tamiamiensis*, USNM 648141, Miocene, Florida; *E.* (*Encope*) *platytata* Jackson (holotype), USNM 324455, Miocene, Canal Zone; *E.* (*Echinadesma*) *emarginata*, USNM 8421, Sabanilla, Columbia; University of California, 33792, locality A-4882 Desterro (now Florianapolis), Brazil; *E.* (*Echinadesma*) *valenciennesii*, USNM 3607, Cumana, Venezuela; *E.* (*Echinadesma*) *micropora*, USNM E1396, Salinas Bay, Nicaragua; *E.* (*Echinadesma*) *californica*, USNM 33206, Galapagos Islands; USNM 10010 La Paz, Mexico; *E.* (*Echinadesma*) *irregularis* H. Clark, USNM E8837, Peru; *E.* (*Echinadesma*) *wetmorei*, USNM E7165, Petatlan Bay, Guerrero, Mexico; *E.* (*Echinadesma*) *perspectiva*, USNM E5635, Lower California; *E.* (*Echinadesma*) *secoensis*, USNM 649218, USNM 649219 (paratypes), Pliocene, Venezuela.

Acknowledgments

I thank Carol Wagner Allison, University of Alaska, for calling my attention to Marten's description of *E. aberrans*; Astrid Witmer, Freie Universität, Berlin, for translating Marten's description; Porter M. Kier for encouraging me to publish these findings and for reviewing the manuscript; J. Wyatt Durham for reviewing the manuscript and the loan of a specimen; David Pawson for constructive criticism of the manuscript; Keith Serafy, University of Maine, who checked the National Collection to determine the distribution of the *Encope* species; I. E. Gray, Duke University Marine Laboratory, for comments on *Encope* distribution and the loan of specimens; and Donna Copeland for typing the manuscript.

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